Nonword Repetition Assesses Phonological Development and Predicts Vocabulary Size in One-Year-Olds

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Young children, it has often been noted, are prodigious word learners, adding items to their mental lexicons at a rate of approximately 9 words per day. The question of interest here concerns the skills children recruit in accomplishing this task. The hypothesis under test is that phonological memory is one of those skills.

1. Phonological memory as a word learning skill

Part of the word learning task is forming lexical entries for newly encountered words, which is, in essence, storing sequences of speech sounds. Phonological memory is the capacity to remember sequences of speech sounds. Not surprisingly, then, a substantial body of research has demonstrated that individual differences in the ability to store novel sound sequences (i.e., phonological memory) are related to individual differences in vocabulary development. In children between 3 and 5 years, phonological memory has been found to predict children’s word learning in a laboratory setting (Gathercole, Hitch, Service, & Martin, 1997) and, in longitudinal studies, to predict actual vocabulary growth (Gathercole & Baddeley, 1989; Gathercole Willis, Emslie, & Baddeley, 1992). Among adolescent foreign language learners, phonological memory is related to success at vocabulary learning in the new language (Service & Kohonen, 1995).

There is also evidence that poor phonological memory skills are characteristic of children with atypical language development. Several researchers have found that phonological memory skills differentiated groups of school-age children with and without language impairment (Conti-Ramsden, 2003; Conti-Ramsden & Hesketh, 2003; Dollaghan & Campbell, 1998; Ellis Weismer, Tomblin, Zhang, Buckwalter, Chynoweth, & Jones, 2000; Gray, 2003; Marton & Schwartz, 2003; Montgomery, 1995).

2. Nonword repetition as test of phonological memory

Nonword repetition tasks have long been used as measures of phonological memory capacity (Coady & Evans, under review). In nonword repetition tasks, an examiner produces a target nonsense word, e.g. *clird*, and the listener repeats the target back to the examiner. Most research that establishes a relation between phonological memory and language development employs nonword repetition accuracy as the measure of phonological memory. It has been found to be independently associated with language development when auditory memory
and intelligence are also measured (e.g., Gathercole & Baddeley, 1989) and to be more strongly associated with language skills than another verbal memory task, digit span (Gathercole, Willis, Baddeley, & Emstie, 1994). Nonword repetition tasks also have high sensitivity for language impairment. In several studies, nonword repetition tasks were able to identify children whose earlier language impairments had resolved (Bishop, North, & Donlan, 1996; Conti-Ramsden, Botting, & Faragher, 2001; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1999).

The use of nonword repetition (NWR) as a measure of phonological memory is not without controversy. NWR has been criticized as not providing a “pure” measure of phonological memory because the task requires multiple abilities (Snowling, Chiat, & Hulme, 1991). One proposal is that that nonword repetition measures a phonological processing ability that underlies both the repetition task and other phonological skills (Bowey (1996; 1997). Other proposed component abilities include speech perception, phonological encoding, phonological assembly, and articulation (Coady & Evans, under review). It has been argued that the dependence of NWR on a set of skills—all related to language acquisition—makes NWR a particularly valuable measure for clinical use (Coady & Evans, under review). However, if the goal is to measure language learning capacity, it is necessary to separate the measure of cognitive-linguistic capacity from a measure of motoric skill. Previous work has found that motoric limitations can affect the meaningfulness of NWR as a measure of phonological memory in very young children and that, despite that, NWR accuracy reflects something other than articulation skill in children as young as 2 years (Gathercole & Adams, 1993; Roy & Chiat, 2004).

3. Sources of individual differences in phonological memory

Phonological memory has been described an unlearned cognitive capacity that differs across individuals (Torgesen, 1996; and see Baddeley, Gathercole, & Papagano, 1998; Montgomery, 2002). Memory capacity, however, depends on a representation system for encoding the to-be-remembered stimuli. For example, adults are better at repeating word sequences that conform to grammatical rules than anomalous word sequences (Miller & Isard, 1963), and chess experts are better at remembering possible middle-game configurations of chess pieces than random arrangements of chess pieces (Chase & Simon, 1973).

A substantial body of evidence similarly argues that phonological memory depends on phonological representations. At age 5 years, children who are better at identifying phonemes and producing rhymes show better phonological memory skills (Bowey, 2001). Adults show better memory for sound sequences that conform to the language they know than for sound sequences in a foreign language (Service & Craik, 1993; Service & Kohonen, 1995; Soares & Hoff, 2000). The wordlikeness of nonwords affects accuracy of repetition (Dollaghan, Biber, & Campbell, 1993) and repetition accuracy is greater for words than for nonwords (Roy & Chiat, 2004).
4. The hypothesized role of phonological development in phonological memory and early word learning

Taken together, the previous research suggests that word learning depends on phonological memory and that phonological memory depends on phonological knowledge. The implication is that children’s word learning, thus, depends to a degree on the phonological knowledge they have achieved.

Virtually all of the research on phonological memory and word learning has studied children 3 years and older. If the current hypothesis concerning the effect of phonological development on phonological memory and thus word learning skill is correct, it is likely to have the greatest explanatory power when phonological development is in progress and when word learning abilities appear to be changing, that is, in the first three years of life.

Pursuing this hypothesis where it is most interesting thus requires a way to assess phonological memory in very young children. Toward that end, the present studies were designed to accomplish the following aims: (1) to develop a procedure for assessing nonword repetition in 1- and 2-year-olds, (2) to establish its comparability as a measure to phonological memory to nonword repetition tests used with older subjects, and (3) to establish its concurrent relation with vocabulary size.

5. Study 1

The goal of Study 1 was to determine whether nonword repetition tasks used with older children could also be used with one- and two-year-old children, and to determine the relationship of nonword repetition accuracy to vocabulary size.

5.1 Method

Twenty-two children ages 20 to 22 months (mean age 20.8 months) participated in a toy naming game. Children were shown a toy by the examiner and asked to repeat the name of the toy, which was a nonword. Nonword stimuli were derived from previous published studies (e.g., Gathercole, Willis, Emslie and Baddeley, 1991). For example, children were shown a sheep and told, “This is grall. Can you say grall?” Accuracy of nonword production was calculated in percent syllables accurately produced. The child’s primary caregiver completed the MacArthur Communicative Development Inventory Short Form, and productive vocabulary percentile was calculated.

5.2 Results

Accuracy of nonword repetition was significantly related to vocabulary percentile, \(r(\text{df} = 20) = .61, p < .01.\)
5.3 Discussion

The results of Study 1 suggest that it is possible to measure nonword repetition performance in children as young as 20 months and that individual differences in this performance are related to vocabulary size. There is a concern, however, that with children this age inaccuracies in nonword repetition might reflect problems with articulation rather than memory. A counter argument is that explaining the significant correlation of nonword repetition with vocabulary at this age would then require positing that articulation is a peripheral impediment to a large productive vocabulary, but that is possible. Study 2 was designed to address this concern.

6. Study 2

In study 2 children were asked to repeat both nonwords and real words, on the logic that real words can be remembered with reference to pre-existing lexical entries but nonwords cannot. Thus, the memory demands of nonword repetition should be greater. The phonemes in real words should not, however, be easier to articulate. Thus, to the degree that children showed inaccuracy in nonword repetition that they did not show in real word repetition, inaccuracy in nonword repetition can be taken as a phonological memory failure, not articulation failure.

6.1 Methods

Sixteen monolingual English-learning children, ages 21 to 24 months (mean age 22.81), were administered a nonword repetition task to assess phonological memory and a real word repetition task to assess articulatory ability with memory demands reduced. Nonword stimuli were the same as in Study 1, and real words were selected from the long form of the MacArthur Communicative Development Inventory (CDI) for 16- to 30-month-olds to correspond to the nonwords in terms of word length and phoneme difficulty. The real and nonword repetition tasks were administered in a toy play activity with the examiner. Children were asked to repeat the names of nine toys (e.g., This is a butterfly, Can you say butterfly?). They were then asked to repeat nonsense word names for another set of nine toys (e.g. This is clird, Can you say clird?). Percent consonants correct for each set of words was calculated for each child. To measure productive vocabulary, the child’s primary caregiver filled out the MacArthur Communicative Development Inventory Short Form. Vocabulary percentile was calculated for each child.

6.2 Results
The findings were the following: repetition accuracy (measured by percent of consonants correct) was greater for real words than nonwords, $t(15) = 2.91, p = .01$, 2-tailed). Both nonword repetition accuracy and real word repetition accuracy were significantly related to vocabulary percentile, $r (df = 14) = .70, p = .001$, and $r (df = 14) = .68, p = .002$, respectively. Nonword repetition accuracy was related to real word repetition accuracy ($r (df = 14) = .65, p = .003$).

The most important finding was that when the variance correlated with real word repetition accuracy was removed, children’s nonword repetition accuracy was significantly related to their vocabulary percentile ($r (df = 13) = .46, p = .04$).

6.3 Discussion

The finding that real word repetition was more accurate than nonword repetition supports the assumption that the memory demands of the real word repetition task were less than the memory demands of the nonword repetition task. Put another way, nonword repetition required something more than did the real word repetition task. We conclude that that something more is the capacity to store phonemes. Individual differences in that capacity are captured in these data in the form of the variance in nonword repetition accuracy that is not explained by real word repetition accuracy. That residual variance was significantly related to vocabulary size.

7. General conclusions

The results of these two studies support two conclusions: (1) Nonword repetition accuracy reflects phonological memory capacity, not just articulation skill, in children under 2 years, and (2) At this early point in both phonological and lexical development, phonological memory capacity is related to vocabulary size.

8. Further questions and future directions

These two studies are only a beginning. One necessary next step is to replicate these findings with stimuli in which the phonetic inventory of English is better represented and in which the real words and nonwords are better matched in terms of phoneme distribution, word stress patterns, word shape, and phonotactic probability of phoneme sequences. To better specify the nature of the relation between phonological memory and word learning skill, it will also be useful to compare the correlation to vocabulary size of different ways of measuring accuracy of real and nonword repetition. For example, if word shape in addition to individual phonemes is stored, then a measure of accuracy that makes use of word shape should predict vocabulary better than a measure than only takes into account phoneme accuracy.
The development of a method for assessing phonological memory in very young children is only a means to addressing the bigger questions about the relation of phonological development to lexical development with which we began. It will require further studies to investigate the degree to which phonological memory is a function of phonological development. Comparing nonword repetition accuracy and its relation to vocabulary size, in both languages being learned by bilingual children is one way to separate the unlearned and learned contributions to phonological memory. To test the hypothesis that phonological memory capacity contributes to lexical growth, longitudinal studies will be necessary.

References


Coady, J. A. & Evans, J. L. (under review). The uses and interpretations of nonword repetition tasks in children with and without specific language impairments.


